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PROGRAMME MATTERS

Updated list of selected environmentally harmful chemical substances, processes and phenomena of global significance

Report of the Executive Director

Summary

The present report is being submitted in compliance with Governing Council decision 14/32, in which the Executive Director was requested to submit an updated report, as well as to obtain the comments of Governments, relevant international organizations, industry and non-governmental organizations on the list of selected environmentally harmful chemical substances, processes and phenomena of global significance (UNEP/GC.14/19) and to submit an updated version of the report to the Governing Council at its sixteenth session, taking into consideration the comments and suggestions received.

Following an explanation of the report's objectives and of the approach adopted in its formulation, including the criteria applied for the identification of the environmentally harmful chemical substances, processes and phenomena of global significance, seven themes are identified. These were selected because the processes and phenomena they covered were all related to the harmful characteristics of chemical substances. They are: acidification; air pollution; eutrophication; oil pollution; pollution due to agricultural activities; pollution due to industrial chemicals; and wastes. A brief description is given of each process or phenomenon, followed by a summary of its impact on humans and the environment, and a set of control measures. Finally, recommendations are made with regard to each category.

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Suggested action by the Governing Council

The Governing Council may wish to:

1. Note the updated report of the Executive Director;

2. Request the Executive Director to:

(a) Refer the report to Governments, relevant international organizations, industry and non-governmental organizations for further study and action, as appropriate;

(b) Obtain their comments on the report, in particular on the recommendations contained therein;

(c) Submit an updated version of the present report to the Governing Council in 1993, taking into consideration the comments and suggestions received.

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INTRODUCTION

1. The Governing Council, at its ninth session in 1981 (by its decision 9/6), recognized that the preparation of a list of environmentally dangerous chemical substances harmful at the global level, to which special attention should be paid in short-term and long-term environmental policies, would contribute to the promotion of public awareness of their possible environmental hazards.

2. Such a list was prepared by UNEP and was continuously updated with the assistance of expert groups, and circulated among Governments, international organizations, industry and non-governmental organizations for action and comments, at the request of the Governing Council. As the list evolved, certain harmful processes and phenomena involving chemicals were also included. Pollution due to infectious biological material and radiation have been excluded from the list.

3. At its fourteenth session in 1987 the Governing Council (by its decision 14/32) requested the Executive Director to submit an updated report for the sixteenth session in 1991. An expert consultation, held in February 1990, recommended that specific monographs be compiled in relation to industrial and environmental processes and phenomena of global significance involving chemicals, and suggested seven such themes, viz. acidification; air pollution; eutrophication; oil pollution; pollution due to agricultural activities; pollution due to industrial chemicals and wastes.

4. This report contains short executive summaries of each of these monographs with recommendations for action. The monographs with full bibliographic references will be published at a later date.

I. OBJECTIVES

5. The purpose of this report is to stimulate awareness among Governments and the public about the hazards of chemical contamination of the environment, so that necessary measures may be adopted to prevent serious impacts. Pollution prevention pays. In view of the uncertainty about possible time-delayed responses and the frequent irreversibility of the effects caused by dispersion of chemicals in the environment, a precautionary general approach to any further pollution of the environment by chemicals is justified.

6. Chemicals that are widely distributed in the environment in significant quantities by human activities represent potential threats to ecosystems, as well as to human health, both through immediate or time-delayed responses. The choice of problems listed in this report reflects the need to protect ecosystems as well as human health and the socio-economic interests of present and future generations, and to achieve ecologically sustainable use of chemicals.

7. Management of the risks associated with exposure to certain chemicals or groups of chemicals should take place preferably in the context of the process in which they are produced or used, or the environmental phenomenon in which they play a critical role. In order to reflect more readily current environmental, ecosystem and health concerns, the chemical substances selected for inclusion in the present report have been categorized mainly by their relationship to, and effects on, environmental processes. Thus newly

identified substances of concern in a process, or resulting from a modified process, can be readily included in future updates. Mixtures of pollutants, which commonly take place in reality pose problems of additional complexity.

8. Certain chemical problems like those related to climatic change and effects on the ozone layer are not listed, although they are the subject of substantial concern and careful consideration. They are excluded here because they are already specifically being dealt with by UNEP and other international organizations.

9. The list is not exhaustive or final, but is a step in the continuing process of identifying global environmental and human health priorities. It is intended as a basis for action by both international and national organizations.

II. APPROACH

A. Definitions

10. Chemicals of global significance are here considered as those which prevail widely in the environment in significant quantities as a result of their transport through air, water and food chains, or because they are present in commodities or traded internationally on a large scale. Chemicals of global environmental significance also include those that have regional or local significance, but that appear so frequently as to cause common concern in a large number of countries. Harmful chemicals can be defined as those that enter the environment as the product or the by-product of human activities, that appear to pose (directly or indirectly) a real threat to human beings and the environment, and that, at least now, can be eliminated from the environment only with difficulty. A harmful chemical phenomenon and/or process is any important event related to adverse effects due to chemical pollution, such as eutrophication or the incremental build-up of concentrations of potentially toxic chemicals in soils, sediments and groundwater.

11. This report identifies seven processes or phenomena involving chemicals affecting the environment in large quantities and that may place human health and the environment at risk. It focuses on processes that are hazardous in a global sense, using criteria that must be satisfied for a chemical to be regarded as having global significance and criteria that determine the threat to human beings and the environment. Hazardous products from chemical processes, such as wastes of ill-defined chemical composition are also included.

B. Criteria

12. Information on the distribution and behaviour and harmful effects of chemicals needs to be evaluated in accordance with the following criteria:

(a) Production, distribution and release;

(b) Secondary substances and by-products;

(c) Persistence and transformation;

(d) Accumulation, concentration and biomagnification;

(e) Susceptible populations and ecosystems;

(f) Toxicity and exposure;

(g) Effects on the physical and chemical environment;

(h) Effects of physical factors and littering.

Each of these criteria is examined in detail below.

(a) Production, distribution and release

13. Potential global significance is determined by applying the following considerations:

(a) Quantity and trend of production of a chemical, including its relative contribution to pollution, during its entire life cycle and the geographical distribution of production centres;

(b) The type of use, potential for inappropriate use, wastefulness of use; potential and likelihood for reuse; and ways and means of waste treatment or disposal, including by-products of its management as a waste.

(b) Secondary substances, by-products

14. In most cases, chemicals are not pure compounds, but mixtures. Impurities, although at low levels, may be so toxic as to be in fact more significant than the primary compound. Chemical products as released may consist of complicated mixtures, the toxicity of each component being poorly understood. Additives - for example carriers, emulsifiers, and dispersants - may also significantly alter the toxicity of the product or change the selectivity of the effective toxicity of the primary compound.

(c) Persistence and transformation

15. Mobility in the environment of widely dispersed persistent chemicals can result in an even larger number of organisms, ecosystems, and human populations being exposed, and in trespassing upon or overloading the carrying capacities of soils, sediments and groundwater. In many cases, injury to organisms can take place in areas remote from the point of release. Persistence of a chemical increases the possibility of this happening; furthermore, persistence means that corrective measures require a longer time to take effect. The persistence of an organic chemical is influenced by temperature, humidity and biotic richness and stability of an ecosystem. Transformation or (bio)degradation products of organic chemicals must also be considered, as they may be more persistent or toxic than the original chemical.

(d) Accumulation, concentration and biomagnification

16. The absorption of chemicals into soils, sediments and suspended particles decreases their availability for degradation and thus may result in long-term accumulation with unknown consequences. Erosion (by water or wind) may redistribute and even concentrate toxic materials in sediments. Furthermore, organisms can selectively take up toxic substances from their food, water and air, and store them in tissues or organs (bioaccumulation, including

bioconcentration), which are then specifically exposed. Some chemicals increase in concentration along food chains from plants to herbivores to carnivores and thence to human beings. These processes can lead to toxic concentrations within the organisms higher up in the food chain, which may then adversely affect entire life communities.

(e) Susceptible populations and ecosystems

17. Although global dispersal of a chemical puts any population (human or non-human) at risk, distribution, however, tends not to be uniform. Due consideration should therefore be given to specific populations or communities that are at higher risk, also taking into account current natural background levels. Furthermore, if only one or few species in an ecosystem are directly affected, the whole life of the community can be significantly changed. Global acidification may even disrupt coherence of circumpolar habitats. Special attention should be paid to endangered species.

(f) Toxicity and exposure

18. Toxicity refers to the potential of a chemical to cause harm to organisms, either acute or chronic, or even delayed in time to future generations. Although organisms may be exposed to relatively high environmental concentrations of chemicals, it is only the bio-available fraction (i.e. the specific form that penetrates through skin or other membranes) that causes the risk. Most of the pollutant that does not exist in a bio-available form goes into the soil, sediment or groundwater and can become bio-available after transformations due to land-use changes, climatic change, erosion, oxydation/reduction, etc.

(g) Effects on the physical and chemical environment

19. Chemicals may not exert direct toxic effects on organisms, but may instead affect some abiotic parameter of the environment, such as radiative absorption (influencing the climate) and atmospheric composition (destruction of the ozone layer; formation of smog), or the physical properties of soils (changing erodibility or compaction).

(h) Effects of physical changes and littering

20. Physical changes of the environment (digging, flooding, drainage) can release chemicals accumulated in soils or sediments. Discarded materials, including man-made filaments, nets and solid plastics may by their physical nature affect local populations of sea mammals and birds.

C. Follow-up activities

21. The Governing Council, by its decision 14/32 of June 1987, noted that comments were received from 28 countries, 12 international organizations, and 11 industrial and non-governmental organizations on the list issued in 1984. It also noted that none of the replies referred to action measures.

22. The 1987 update was referred to Governments, relevant international organizations and industrial and non-governmental organizations for further study and action as appropriate. In reply to this request, comments have been received from 14 countries, 19 international organizations and 5 industrial and non-governmental organizations as at 15 January 1991.

23. Governments should take into consideration the recommendations set forth in this report. The recommendations should be incorporated as far as possible into appropriate existing national activities, as well as new ones to be initiated. Governments should implement, ratify and enforce relevant existing and future international and national legislation. Furthermore, Governments should ensure that UNEP is kept regularly informed of relevant activities being undertaken in this field as well as of results obtained.

24. Actions to be taken are:

- To establish a continuous process of chemical risk assessment to identify priorities;
- To initiate activities aimed at reducing pollution by chemicals that have been identified;
- To reduce pollution by chemicals according to predetermined targets;
- To monitor achievements in reducing pollution by appropriate criteria;
- To educate users and producers of the hazards of the substances concerned.

25. Where appropriate, such activities should be internationally co-ordinated with the active participation of the relevant international agencies and organizations for the purpose of promulgating guidelines, assisting in training activities, disseminating of information, etc. It is to be expected that the substances, processes and phenomena selected in this list will be incorporated into the action plan of UNEP's Earthwatch.

III. EXECUTIVE SUMMARIES WITH RECOMMENDATIONS

A. Acidification

1. Background

26. Acidification can be considered as change toward more acidic conditions in one or more compartments of the biosphere or reflection of the processes that bring about these changes. There are many natural causes of acidification, but it is generally agreed that the major anthropogenic cause of acidification is the emission of sulphur and nitrogen oxides into the atmosphere. These emissions occur primarily as a result of the combustion of fossil fuels and the smelting of sulphur-rich ores, while other major sources of acid gases include the burning of biomass.

27. Once in the atmosphere, the acidic gases are oxidized and transported as gases, aerosols or cloud droplets in prevailing airstreams before being subject to either wet or dry deposition. Dry deposition generally occurs close to emission sources, whereas wet deposition may occur after long-range transport. The presence of these acidic substances in precipitation can significantly lower its pH and average levels below 5.0 suggest probable anthropogenic influences. Acidic fogs, dews and episodic instances of acid rainfall and snow have been shown to have pH values well below 3.0.

28. Acidification problems are most severe where there is a combination of increased acid gas emission and sensitive soils. Initially, this was reported in northwest Europe and northeastern USA, but other regions, such as the southwest provinces of China are now affected. Globally there are many other areas, on all continents, that are already affected. Areas with sensitive soils and rapid industrial development are particularly at risk.

2. Human and environmental impact

29. The effects of these acidic deposition processes have been observed in terrestrial and aquatic ecosystems, on human constructions, as well as on human health. Direct effects occur where acidic deposition comes into contact with susceptible surfaces, while indirect effects occur where acid precipitation disturbs the natural balance of nitrogen and sulphur in the biogeochemical cycles of these elements.

30. In terrestrial ecosystems that are poorly buffered, increased hydrogen ion concentrations mobilize cations that are leached from the soils, leading to pH decline. The leaching of calcium and magnesium will be followed by mobilization of aluminium, manganese and other metallic ions, depending on soil type. Leachates from affected soils run off into aquatic ecosystems that may also become acidified.

31. Forest decline has been cited as the most obvious evidence for the impact of acidification on terrestrial ecosystems. Certainly foliar damage is particularly evident in the high elevation forests of Europe and North America where clouds, mist and fog are highly acidic. The most significant effect of acidification on forests may prove to be due to nutrient leaching, leading to reduced growth and productivity, and there is also evidence for the toxic effects of aluminium mobilized by acid soil water. However, the evidence for causal relationships between the effects of acidification and forest decline is complex. In some instances, it is considered to be of major importance, while in other forest regions, multiple stress factors are implicated.

32. In freshwater ecosystems it has been widely reported that low pH is correlated with the loss of fish from lakes and fish kills in streams. These losses are attributed to both direct toxicity (for example from highly acid meltwaters) and indirect toxicity arising from the release of aluminium from sediments and soils. Other effects include reductions in food chain diversity and lowered biological productivity. Increases in nitrogen availability may, by contrast, lead to eutrophication of lakes and enclosed seas.

33. The impact of acidification on human health may be direct, through the inhalation of acid aerosols, or indirect, where increasing metallo-solvency leads to the leaching of potentially toxic metals into drinking water from watersheds, sediments and plumbing.

34. All materials suffer degradation from natural weathering processes, but air pollution has accelerated degradation rates. Acidic deposition causes corrosion and other damage to a wide variety of buildings and other material forms of cultural heritage. The influence of nitrogen oxides (NO_x) alone on corrosion is small, but recent studies show that significant effects can occur where nitric acid deposition is high and that nitrogen dioxide (NO_2) in combination with sulphur dioxide (SO_2) has a synergistic effect. Corrosion of underground structures will be affected by reductions in soil pH.

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3. Control measures

35. The application of current monitoring and modelling of acidic pollutants and deposition and studies of terrestrial ecosystem damage, including critical load assessments for sulphur and nitrogen, should be intensified to include all regions and thus provide world-wide coverage. Detailed mapping of the global distribution of acidic deposition and acid sensitive soils should also be undertaken. Remedial measures such as liming may be effective only on a localized scale.

4. Recommendations

36. (a) Improvement of monitoring and control measures is necessary;

(b) With the predicted global rise of NO_x emissions, greater attention needs to be directed towards the impacts of these gases on all acidification and related processes, including eutrophication, primary and secondary plant productivity and tropospheric ozone formation;

(c) The long-range nature of acid deposition and associated effects requires the further development of national and international agreements on control measures to reduce further sulphur emissions and transboundary fluxes and address the increasing levels of NO_x. Preventive policies should include not only source emission control, but also clean fuel and energy conservation strategies and alternative energy sources.

B. Air pollution

1. Background

37. Air pollution is defined here as the presence in the outdoor and indoor atmosphere of one or more gaseous, aerosol or particulate contaminants in quantities, characteristics, and of duration such as to be injurious to human, plant or animal life or to property, or which unreasonably interferes with enjoyment of life and property.

38. Air pollution problems may vary greatly with the geography, demography and socio-economic profile of a region. These factors will determine the sources and emission rates of the pollutants. The climate and topography of a region will influence the distribution and atmospheric processes affecting the pollutants, and ultimately their effect upon the environment and human health.

39. The increase in fossil fuel combustion since the industrial revolution has led to a concomitant rise in polluting emissions. It is currently estimated that 90 per cent of the total global primary energy is consumed in the industrialized northern hemisphere. The rapid industrialization of many developing countries will inevitably increase energy demand and consequently lead to increased polluting emissions. Decrements in air quality due to increasing urbanization and motor vehicle use have occurred throughout the world in recent years. Certain air pollutants are subject to long-range transport, thereby affecting a large number of people and environments.

Stationary sources:

40. The combustion of fossil fuels to generate electricity and to provide power for industrial processes leads to the production of large quantities of certain air pollutants, most significantly carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NO_x), organics and also primary particulates (fly ash, soot and other particulates) and secondary particulates (acid aerosols). Other pollutants, such as hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs), and trace metals (arsenic, cadmium, lead and mercury) often are absorbed on the surface of particulate matter. The size and composition of particulate matter varies greatly. The use of high chimneys for dispersal from major point sources has resulted in long-range transport and air pollution. Domestic solid fuel use, mainly coal and wood, for heating and cooking may significantly contribute to pollution levels, especially in cities.

41. Various industrial processes and agricultural activities also contribute to atmospheric pollutant emissions and are discussed elsewhere in the report. Of particular concern are emissions of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) from waste incineration, trace metals from metal production and fluorine from aluminium and brick production.

Mobile sources:

42. Motor vehicles are now the major factor influencing air quality in developed countries and many developing cities throughout the world. Petrol-driven motor vehicles are the principal source of carbon monoxide (CO), NO_x, volatile organic compounds (VOCs) and lead. Emissions of NOx and VOCs play an important role in the formation of secondary photochemical oxidants such as nitrogen dioxide (NO_2), tropospheric ozone (O_3), and peroxyacetylnitrate (PAN). The world motor vehicle population is projected to double by 2030 and therefore problems associated with photochemical smog are likely to increase despite stringent control measures in developed countries. Emissions from diesel vehicles also pose a threat to urban and regional air quality. Increasing levels of carbonaceous particulates and polycyclic aromatic hydrocarbons (PAHs) have been associated with the increasing use of diesel vehicles.

Indoor air pollution:

43. In temperate regions, people spend approximately 90 per cent of their time indoors and buildings in these regions tend to have a low air exchange rate resulting in indoor concentrations exceeding those outdoors, where sources are present. Such indoor air pollution arises from combustion in space heaters and stoves (CO, NO_x and smoke), building materials, furniture, carpets and domestic chemicals (formaldehyde, VOCs and biological aerosols) and the ground under buildings (radon and methane). In many developing countries, indoor air pollution problems are associated with the use of solid fuel stoves, resulting in high exposures to combustion gases and particulate matter.

2. Human and environmental impact

44. Human health effects vary according to the intensity and duration of exposure and the health status of the population exposed. Although exposure may vary greatly, depending upon the location and activity of the individual, there is a considerable lack of knowledge in this area. The response of

populations to air pollution is influenced by other environmental and life-style factors. Certain members of the population may be at greater risk, such as those suffering from respiratory and cardiopulmonary disease, pregnant women, infants, the elderly, the hyper-reactive and people exercising. Some of these groups may be confined indoors and are therefore at greater risk from indoor air pollutants.

45. The increased mortality, morbidity and deficits in pulmonary function associated with annual and daily mean SO_2 and suspended particulate matter concentrations well above WHO guideline values are widely documented. Some reductions in health risk have occurred in many developed countries over the past twenty years due to "clean air" legislation and control measures. In many developing and eastern European countries, SO_2 and particulate matter levels have increased due to reliance on coal as an energy source. In developing countries, decreased lung function and increased rates of acute respiratory infection (ARI) and chronic obstructive lung disease have been observed in women and children exposed to smoke from solid fuel stoves. ARI is one of the main causes of infant mortality in developing countries.

46. Exposure to automotive air pollutants is increasing especially in the cities of developing countries. It is estimated that 300-400 million city dwellers in developing regions will be exposed to unhealthy levels of air pollution by the end of the century. Motor vehicle emissions are implicated in a wide range of health effects. Exposure to CO can result in cardiovascular and neurobehavioural effects. NO_2 often acts synergistically with other pollutants and in particular other photochemical oxidants such as O_3. Acute exposure to O_3 levels above guidelines changes inflammatory and permeability responses, lung functions and airway reactivity. Photochemical oxidants and certain volatile organic compounds (e.g., toluene) are factors in eye, central nervous system and mucosal irritation.

47. PAHs from various sources (including diesel vehicles) may have carcinogenic or mutagenic effects. Evaporative and exhaust emissions of benzene from motor vehicles are of particular concern, as exposure can result in excess incidences of leukemia.

48. Exposure to lead (see paragraph 100 below) is important where tetra-ethyl lead is still a major fuel additive. Levels of tetra-ethyl lead in petrol have been reduced and even phased out in many developed countries.

49. Increasing energy demand in many countries will inevitably result in greater fossil fuel use in the short- to medium-term and therefore increase carbon dioxide production. It is now generally accepted that the increase in atmospheric CO_2, together with other greenhouse gases will lead to an increase in average global temperature.

50. Pollutants such as SO_2, NO_x and O_3 directly affect plants in several ways. This may reduce primary productivity of terrestrial ecosystems and biomass production. The response of plants to atmospheric pollutants is increased by other stresses, such as pests, drought and disease. Long-range transport of these pollutants may further increase levels affecting vegetation. Local fluorine emissions may also damage forest ecosystems, crops and grazing animals.

51. Air pollution can cause direct damage to structures and materials. SO_2 and other acid gases are known to cause corrosion of metals, surface erosion and soiling of building stone and glass, discoloration of paper and reduced tensile strength in textiles. Ozone and NO_x fade textile dyes and paint pigments and also oxidize rubber.

3. Control measures

52. Air quality monitoring is a basis for setting up appropriate control strategies. Accurate emission inventories at all levels and strict emission standards are essential in the implementation of such control strategies.

53. Among the technical options to reduce emission from stationary sources are greater energy conservation and the introduction of high efficiency generators, cogeneration and fuel cells, as well as the use of less polluting fuels such as natural gas.

54. Emission from mobile sources should be considered in the broader context of urban transportation planning, including the further promotion of public transport. Low exhaust emission engines and emission control devices for all petrol and diesel vehicles are the technical options to reduce emission from individual sources. The less polluting alternative fuels and electrically powered vehicles should be encouraged.

4. Recommendations

55. (a) Governments should develop control strategies for continued reduction of atmospheric pollution according to set targets. It is essential that national monitoring data on which to base control strategies are available;

(b) Countries should maintain or initiate air quality monitoring of CO, NO_x, O_3, SO_2 and acid aerosols, and submit data to intergovernmental organizations for global evaluation. Monitoring of respirable particulates (PM_{10}) should also be initiated in all monitoring networks;

(c) Governments should increase research to enhance end-use efficiency and to encourage technological advances and the use of less polluting fuels, including non-carbon energy sources;

(d) Where use of fossil fuels (coal, fuel, oil) must be continued for the immediate future, technologies should be further developed and applied in the field of fuel treatment and clean combustion;

(e) Effective land use planning, such as industrial zoning, and assimilative capacity-based environmental impact assessment of potential air pollution sources is essential in order to reduce damage to the environment of adjacent areas, including forest ecosystems and agriculture.

C. Eutrophication

1. Background

56. Eutrophication is the biological consequence of increased concentrations of inorganic plant nutrients and can occur in both terrestrial and aquatic ecosystems. Terrestrial eutrophication results from the application of

fertilizers and is characterized by a reduction in species diversity. Of greater significance is the phenomenon of aquatic eutrophication.

57. For the purpose of this document, the word eutrophication is defined as the excessive fertilization by nutrients (primarily phosphorus and nitrogen compounds) of lakes, reservoirs, slow-flowing rivers and certain marine coastal waters that results in the nuisance growth of aquatic plant material, such as algae and floating plants. This in turn leads to water quality plant deterioration, taste and odour problems, oxygen depletion, reduced transparency, decline of fisheries, possible fish kills, clogging of waterways and toxic effects on humans and animals. An assessment of the trophic status of the world's lakes and reservoirs indicates that some 30 to 40 per cent are affected by eutrophication. Currently global eutrophication of the oceans is not a serious problem, but the increasing deterioration of many coastal marine waters should be taken as a serious signal. There is an increasing occurrence of eutrophication on a global scale with a concomitant human and environmental impact.

58. There is no doubt that the man-made accelerated eutrophication is caused by an increased load of nutrients far above the natural level. The relative contribution of point sources, such as discharge of animal and human waste and industrial waste discharges, and diffuse sources, such as fertilizer leaching, soil run-off and atmospheric deposition, may differ from place to place. A distinction has to be made between eutrophication of inland waters, which is largely due to non-point sources (air pollution, agriculture), and marine eutrophication, which is mainly due to discharge of wastes into coastal waters, deposition from the air and pollution from ships, and offshore activities (mining).

2. Human and environmental impact

59. Eutrophication in surface waters may be regarded as a disturbed balance of the trophic levels in the ecosystem resulting in destabilization of the normal regulative mechanisms on the species distribution, leading to reduced biological diversity and frequently, to explosive growth of a few single algal or macrophyte species. When they decay, they cause severe deoxygenation of the water column, the release of sulphide and nitrite, and massive fish kills. Deoxygenation does not only kill valuable aquatic life, but also threatens human health by rendering scarce fresh water unsuitable for drinking. Reduced transparency caused by algae in the water column results for example in the decline of rooted aquatic plants and of corals, together with associated fish communities. Also, the increasing occurrence of toxin-producing algal blooms is a worrying phenomenon. Despite high primary productivity in over-enriched water, secondary productivity may be strongly affected, producing an imbalance. The production of herbivorous fish species is increased. On the other hand, a large decrease in the productivity of fish species of economic importance (salmonids, for example) usually occurs.

60. Large populations of aquatic plants may prevent or inhibit the utilization of water resources by humans in a variety of ways. Moreover, aquatic weeds provide a suitable habitat and food supply for vectors of many tropical human diseases. Last but not least, the increased loss of water by evapotranspiration from emergent plants may be of significance, and increased organic matter in sediments may entrap heavy metals and organic chemicals.

3. Control measures

61. Reduction of eutrophication can be achieved through measures to reduce the sources and measures to reduce the effects. One preventive measure is to remove nutrients from waste water.

62. In order to reduce inputs from agriculture, nutrient addition to crops should be in balance with nutrient uptake. Further reduction of inputs can be achieved by such measures as careful dosing of fertilizer and manure, increasing the use of "green manuring" (which will lead to a reduced use of fertilizers), prevention of soil erosion, transfer of surplus nutrients to nutrient poor regions, denitrification of manure and the recycling of nutrients on a regional scale.

63. The effects of eutrophication can be mitigated by influencing the balance between algal production and consumption by other organisms. Where aquatic plants are the dominant problem, consumers of aquatic plants, such as grazing fish and geese, can be used after careful consideration of the ecological consequences. Harvesting of aquatic plants can be a very effective method of reducing nutrients in the water, but their disposal may be a problem. The use of pesticides against aquatic weeds is of no use for controlling eutrophication. Mechanical and chemical measures may be used to speed up the recovery by other methods. Examples are dredging, the precipitation of metal-phosphate complexes and oxygenation of the water column.

64. Eutrophication can be controlled effectively only by drastic reduction of the total nutrient load of an overloaded water body. Partial reduction of the source that is easiest to tackle generally will not bring significant improvement. Even after drastic reduction of all sources, it may take many years before a eutrophic ecosystem recovers.

65. The control and prevention of eutrophication will be successful only through the use of an integrated approach, based on a catchment area's nutrient mass balance and taking into consideration specific geographical, climatological and ecological conditions.

4. Recommendations

66. (a) Control measures as outlined above should be implemented and regulations should be enforced as soon as possible. Governments should consider organizing catchment-wide systems of control that includes water, soil and air, and land-use activities;

(b) International co-operation should be encouraged especially for the use of remote sensing techniques as a very helpful method of monitoring the algal concentrations of many water bodies;

(c) Industrial sources of nutrients should be reduced; for example, discharge of phosphogypsum by phosphoric acid producers should be stopped.

D. Oil pollution

1. Background

67. Petroleum and its products are complex materials that undergo many compositional changes in the environment. Hydrocarbons derived from petroleum

are the leading contaminants, in prevalence and quantity, especially in groundwater and the ocean, given their global production, transport, use, disposal and spillages. Approximately 3.2 million metric tonnes per year enter the marine environment. Conservation and prudent use of petroleum are critical to counteract oil pollution arising from atmospheric, liquid and waste emissions from exploration activities through the final disposal of products.

68. Sources of pollution on land and in freshwater include leaks and spills from vessels, pipelines, storage tanks, shoreline facilities, airborne contaminants and land runoff. Cumulative effects of such discharges occur in many places. Losses of lubricating oils containing heavy metals and hydrocarbons such as PAHs in municipal effluents are a chronic surface water problem. Increasing groundwater contamination from leaking storage facilities and pipelines is a serious problem in many countries.

69. Sources of oil include land-based activities, marine transportation, the atmosphere and offshore production. In marine environments, about 92 per cent of petroleum input is anthropogenic with unwanted releases via routine, chronic discharges from storage areas and along major tanker routes and via accidental events such as oil spills and pipeline ruptures. Petroleum concentrations and tar accumulations are higher in major shipping lanes compared to the rest of the open ocean. Total floating tar declined by 13 per cent from 1975 to 1985. The highest concentrations continue to occur in the Sargasso and Mediterranean Seas. Tanker spills contribute about 15 per cent of oil input, but volumes spilled annually are highly variable, making trend identification difficult. Tar continues to impair the amenity of beaches. Although oil spills and tar are highly visible, oil inputs from land-based sources are of increasing concern, especially near urban centres.

2. Environmental impact

70. When hydrocarbons enter water and soil, bacteria are the primary decomposer. Oil persists at low temperatures and in groundwater. The source and composition of the crude petroleum is also a factor. Biological effects are similar in tropical, temperate and polar environments for related or similar organisms and processes. Important latitudinal differences in these effects are those involving the distribution and composition of hydrocarbons, including their weathering, persistence, and uptake by biota. Marshes and mangroves are especially vulnerable to oiling. Wildlife are often the most conspicuous victims of oil spills. Many biological effects induced by hydrocarbons have been measured and some patterns are apparent: generally, young life stages are more sensitive than adult, and crustaceans are more sensitive than fish. Extrapolating results from confined laboratory organisms to complex field communities is difficult, but progress has been made through large tank and field studies. There is increasing evidence of mutagenic and carcinogenic effects of petroleum components and the ecological risk of chronic sources of contamination is probably much larger than estimated to date.

71. There is evidence concerning long-term population and community level effects from petroleum. Often a decade or more is needed for oil-polluted communities to recover to their pre-spill states. Polar ecosystems experience long-term exposure after spills due to slow hydrocarbon degradation. Tropical ecosystems, such as mangroves, coral reefs and seagrasses, are particularly

vulnerable and sensitive; damaged coastlines may prematurely erode and important habitats be lost. Too little is known about the time scales and recovery patterns of such ecosystems after acute and chronic pollution.

3. Control measures

72. Managing global oil pollution requires greater attention. Management includes not only environmental protection planning to anticipate and avoid chronic discharges, but also contingency planning for accidental events. Sensitivity mapping is important to identify priority protection for sensitive environments. Improved oil spill control and cleaning methods can be shared regionally. Co-ordinated surveillance of monitoring programmes give feedback to management on general trends, compliance with legislation, and amount of ecological damage. Methods and field designs are being improved and standardized to ensure better accuracy and consistency in their results. The involvement of both oil-producing and non-producing countries through enhanced legislation, ratification and enforcement of agreements at national and international levels and by co-operative arrangements will combat both marine and land-based sources of pollution. Improved prevention measures include education on the use and conservation of petroleum and development of land and sea-based environmental assessments and management plans for all countries.

4. Recommendations

73. (a) Prevention of global oil pollution should be the priority;

(b) Existing and future conventions (e.g. the 1973 International Convention for the Prevention of Pollution from Ships and its 1978 Protocol) addressing hydrocarbon pollution and control of spills and routine discharges should be ratified and legislation enforced. In particular, attention is drawn to the recently adopted International Convention on Oil Pollution Preparedness, Response and Co-operation (IMO, 1990);

(c) Environmental impact assessments should be carried out for all significant new developments, including exploration activities. Environmental audits should be conducted on existing operations to enable taking actions to minimize discharges and other environmental impacts. Environmental management plans that give practical guidance on reducing risk need to be developed for each country and region;

(d) Methodology should be developed to enable assessment of the long-term economic and social effects of oil spills on aquatic resources;

(e) Development and application of better methods and guidelines for control and clean up operations are needed. Multi-national co-operation, including provision of manpower and equipment for monitoring, control and clean-up, should continue to be pursued;

(f) Global monitoring programmes need to be continued to describe concentrations and distributions of hydrocarbons in all environments and to establish and verify trend data.

E. Pollution due to agricultural activities

1. Background

74. Because of world population growth, increasing agricultural production will be required. The three main ways of increasing availability of food and fibre are: (i) increasing productivity; (ii) increasing the productive area; and (iii) reducing loss. Indirect pollution events, such as those caused by improper use of fertilizer and pesticides, inadequate irrigation and the discharge of wastes, are largely a result of intensification of agriculture. Land use change is a major source of chemicals being mobilized, particularly through erosion.

75. Human health concerns, such as pesticide residues and contaminants in food and occupational exposure, are aspects already covered by programmes of FAO, ILO, WHO and others. The loss of natural habitats and biological species, although an important environmental impact of agriculture are not considered here. They are addressed by IUCN (through the World Conservation Strategy) and other international organizations.

2. Human and environmental impact

76. Direct Pollution: Pollution from agricultural activities can affect air, soil and water. Intensive agriculture often implies the high loading of soils with plant nutrients, the use of many different pesticides and the production of large amounts of waste. However, sound and efficient use of fertilizers maintains and improves soil fertility and their use leads to a more sustainable cropping system.

77. The addition of plant nutrients often exceeds the uptake by the crops. The leaching of agricultural plant nutrients to surface water causes eutrophication (see paragraphs 56-66) whereas contamination of ground water may prevent its use for drinking and may be difficult to reverse.

78. The use of mineral fertilizer may inadvertently add to the metal load of the soil, whereas organic nutrient-rich wastes such as manure, human excreta, sewage, sewage sludge and dredged materials may contribute to the accumulation of contaminants in soil. Properly chosen quality and quantity limits for the application of fertilizers may prevent these problems. A better adaptation of input to the need, supported by modern analytical techniques and better understanding of loss processes (leaching, erosion), may help to reduce the overdosing, often with significant financial savings for farmers.

79. Many pesticides are used to control pests and plant diseases and to protect stored products. Pesticides do not only kill target organisms, but also their predators, parasites and competitors, thus disturbing natural regulation mechanisms and damaging beneficial organisms such as pollinating insects that are vital for many crops. Resistance of pests to chemical control has increased along with pesticide use and leads to an ever-increasing demand for new pesticides.

80. Improper pest management, including choice of a pesticide, may cause a number of side effects with respect to persistence, mobility in soil and toxicity for non-target organisms. Migration of pesticides and their metabolites to surface water and ground water, accumulation in food chains and other ecological effects can be controlled in part by more sophisticated

application techniques, adaptation to seasonal climatic conditions and soil characteristics. The more careful use of properly selected pesticides in an integrated pest management approach can at the same time reduce the amount used and increase the pesticide's efficiency.

81. Agricultural wastes from crops, such as straw, leaves and roots constitute a considerable part of the total production. If such wastes were properly processed to benefit from their energy and nutrient contents, for example by controlled biogasification and recycling to the soil, this could help reduce the world-wide greenhouse effect. However, composting, burning or disposal under uncontrolled aerobic or anaerobic conditions waste energy and cause significant emissions of greenhouse gases. Very severe local pollution often results from the discharge of waste due to the processing of agricultural crops. In these cases also this could be overcome by proper treatment, such as biogasification or controlled aquaculture.

82. The discharge of animal waste from intensive farming to surface water is another significant source of pollution, especially in areas where waste cannot be recycled locally to the soil because of its large quantities or contamination with metals, antibiotics and hormones. These wastes have to be treated so as to take advantage of their energy and fertilizer values. Direct spreading of animal waste over land may result in significant emissions of ammonia that, after atmospheric deposition and microbial conversion, contributes to soil acidification and nitrous oxide emission.

83. Indirect Pollution: Global land use changes due to transformation of forests, wetland and natural grasslands, and desertification due to salinization, overgrazing and erosion pollute the environment in an indirect way, mainly by influencing climate and atmosphere. The comments in this section address only chemical pollution and not environmental effects or species loss through agricultural activity.

84. Burning the carbon fixed in forest biomass and accelerated degradation of organic material in the topsoil after deforestation contributes significantly to the global increase of carbon dioxide in the atmosphere and minerals in the ecosystem. The vulnerability of many deforested soils to rain erosion causes runoff in upstream areas and serious pollution and siltation downstream. Unfortunately, the benefits for agricultural production are often temporary because the new lands are exhausted in a few years and become unproductive, whereas the destroyed ecosystems and habitats cannot be easily restored.

85. Intensive fertilization may also increase significantly the emission of nitrous oxide into the atmosphere. This greenhouse gas is produced as a result of incomplete microbial conversions between ammonia, nitrate and nitrogen. More accurate quantification of nitrous oxide emissions is needed and the conditions leading to microbial generation need to be well known for proper control. Methane emissions are increasing as a result of intensive cattle rearing and flood cropping (rice paddies).

86. In areas where the evaporation exceeds rainfall, artificial irrigation may help to increase productivity. Under such conditions, limited irrigation prevents a drainage of salts from surface soils after evaporation. The salts accumulate in the soil, rendering it toxic to most cultivated crops. As a result, the vegetation cover becomes vulnerable to wind erosion. Salt and

dust from salinated areas pollute neighbouring areas and reduce crop yield. More sophisticated and more expensive irrigation techniques are available, but the need for short-term benefits often prevents their application.

87. Overgrazing of natural grasslands leads to erosion and leaching of minerals, dust storms and water pollution. Bush fires and general mismanagement of soil are other world-wide phenomena that create indirect pollution, particularly by mobilization of minerals, and contribute to air pollution.

88. Wetlands in particular are strongly affected by pesticides and fertilizers from surrounding agricultural activities, which can harm not only their species diversity, but also their soil chemistry and water purity.

3. Control measures

89. Improper agricultural development has contributed to environmental hazards particularly through mishandling of fertilizers and pesticides and inappropriate land use. A major control measure to be applied to combat pollution due to agricultural activities is education of those active in this field at all levels. An awareness awakening programme should be incorporated into graduate and post-graduate programmes in schools of agriculture. In addition, vendors of agricultural chemicals should be trained in all aspects of safe application of pesticides and fertilizer. This should be complemented by the creation or strengthening by Governments of agricultural advisory centres easily accessible for farmers.

4. Recommendations

90. (a) The following principles of sound agricultural practice should be included in education and training programmes:

- Overuse of all forms of fertilizer should be prevented by application of appropriate methods that reduce leaching, denitrification and nitrification and by better adaptation to the actual needs of the crop;

- Soil exhaustion and structure loss should be prevented as far as possible by recycling of organic wastes, biological nitrogen fixation and anti-erosion measures;

- The adoption of proper agricultural waste management must be encouraged to minimize pollution.

(b) Irrigation projects should be based on proper assessment of the specific carrying capacity of the soil. The temporary use of more water than needed to compensate for the evaporation, together with proper drainage, although more expensive, should be recognized to be more cost-effective in the long term for prevention of salinization of soils;

(c) Governments are urged to fully implement the FAO Code of Conduct for the Distribution and Use of Pesticides so as to reduce the risk arising from pesticide use. In particular, registration of pesticides needs an international harmonized methodology for environmental risk assessment, taking into account persistence, mobility, bioaccumulation and toxicity throughout the entire ecosystem at hand;

(d) The marked variation in the susceptibility of the world's ecosystems to pesticides necessitates a full appraisal of the local ecosystem conditions prior to the use of chemical control methods. International organizations should be prepared to assist Governments to make such appraisals.

F. Pollution due to industrial chemicals

1. Background

91. Release of chemicals into the air, water and soils from production, use and accidents may cause global concern for human health and the environment. The harmful effects depend on the production volume, the chemical and biological properties, the source types and pathways of entry into the environment. Much of this information is not known for many of the potentially hazardous chemicals in common use. Consequently, this report concentrates on a limited number of chemical classes and harmful phenomena as examples, choosing those perceived as among the most significant.

92. The enormous growth in the quantity and range of the products of the chemical industry during the past 40 years, in particular the diversity of synthetic organics derived from petroleum, and the concomitant increases in accidents during production or transport emphasize the overall concern about industrial chemicals.

93. Industrial activities contribute to pollution through point source emissions into air, water and soil, through disposal of wastes created during production and through use and disposal of products. Occupational exposures may result in toxic effects on workers and contamination of homes and families. Increasingly, the non-industrial applications of chemicals and even their misuse are causing concern. Among the most important chemicals are certain non-ferrous metals, polyhalogenated organics, solvents and detergents.

94. Although the focus of interest has been effects on humans, environmental effects may also be significant. Some metals are of concern because of their potential toxicity and persistence in the environment. Metals are not produced or destroyed by man, but human activities may transform them.

95. Accidents during production or transport, although rare, may have dramatic consequences for people and the environment within close range. UNEP's Industry and Environment Office and other organizations provide a number of systems and procedures for preventing chemical accidents and minimizing their impact on human health and the environment.

2. Human and environmental impact

Non-ferrous metals:

a. Cadmium

96. Cadmium is of concern because of its ubiquity and increase in the environment, and uptake in food. The primary uses of cadmium are metal plating, pigments and batteries. The use of cadmium in batteries is rapidly increasing. Cadmium is produced from ores containing other metals, so that restriction of use of cadmium in industrial products will probably not reduce the cadmium content of wastes, but will change its distribution in soil and water. Atmospheric deposition may present a significant localized source of

contamination, but it also contributes to soil deposition at long distances from the source. Sewage sludge and phosphate fertilizer are responsible for significant inputs of this metal to agricultural land. Disposal of cadmium containing industrial products contributes to cadmium in household and industrial wastes.

97. In humans cadmium has a long half-life and may produce kidney disease with a concommitant increase in body burden. Evidence of renal tubular dysfunction is increasing in many industrialized countries.

b. Mercury

98. The major uses of mercury are in the chlor-alkali industry, and in the manufacture of scientific and electronic equipment. Though mercury compounds are still used as fungicides, this use is decreasing. However, their use in batteries is still increasing. Additional sources of mercury are air pollution from combustion of fossil fuels, and from industrial activities. A major portion of environmental mercury comes from natural sources.

99. The mercury compound of greatest concern is methyl mercury, because it induces irreversible adverse effects in the central nervous system, particularly in the developing infant, and may be produced from other compounds of mercury in water sediments by anaerobic bacteria. Acidification of lakes and reservoirs contributes to conditions for increased synthesis of methyl mercury from inorganic mercury. Methyl mercury in fresh and sea water is taken up by aquatic plants and marine organisms and eventually, edible fish. Based on food monitoring data from several countries, the general population is not at risk from mercury. The problem may become aggravated in the future, however, due to increasing consumption of predatory sea fish, increasing use of coal as an energy source, and increased availability of mercury from soil and sediments as a result of acidification and other processes. Recent episodes of mercury intoxication and environmental pollution have followed the use of mercury compounds in the mining of gold.

c. Lead

100. Industrial uses of lead include batteries, solder and pigments. Lead exposure of urban populations takes place partly through inhalation, but appreciable amounts are taken up from the food. Children may ingest significant amounts of lead from dust, paint and soil. Of special concern are the effects of low levels on the central nervous system in children, reflected in impaired performance and cognitive ability. Biological monitoring data show that undesirably high blood lead levels are still present in many adults and children throughout the world. The reduction of lead in gasoline and its reduction in other uses (e.g. canned food and paint) has resulted in a significant reduction of blood lead levels in some countries. Large numbers of aquatic birds are poisoned by lead through the ingestion of spent lead gun shot.

Arsenic:

101. The toxicity of arsenic is well known, and inorganic arsenic is a human carcinogen. Arsenic has comparatively few uses now, but two are particularly significant: the use of arsenate pesticides, and its use in wood preservation formulations. Both uses can lead to environmental contamination, directly in the case of the pesticidal use, and indirectly if the treated wood is burned;

arsenic trioxide will be present in the smoke. However, arsenic is ubiquitous and occurs in virtually all minerals. Thus, the release of arsenic to the environment is quantitatively much greater from mineral processing (including coal combustion) than from the deliberate production and use of arsenical compounds. Certain areas of the world show effects of arsenic contamination of water resources. However, in some cases the effects are at least partly due to naturally high geological concentrations of arsenic.

Polyhalogenated Organics:

102. This is a very large group of environmentally significant compounds. Those which have been selected for consideration are: polychlorinated biphenyls (PCB); polychlorinated phenols (PCP); chlorinated hydrocarbons; polychlorinated dibenzodioxins and dibenzofurans (PCDD and PCDF); and some brominated compounds.

103. Characteristics of polyhalogenated compounds of environmental significance include their chemical stability, which makes them persistent, and their fat solubility, which causes their concentration in fats and fatty organs leading to bioaccumulation and accumulation in soils and sediments. The group shows a very wide range of acute toxicities from virtually non-toxic to extremely toxic. In addition several organohalogen compounds are implicated in carcinogenesis, mutagenesis and teratogenesis. Organohalogens contribute to the depletion of the ozone layer. They are made in quantities ranging from very small to very large and find widespread uses in industry and in consumer products. Among these uses are: solvents; pesticides; plastics; plasticizers; insulation; flame retardants; and disinfectants.

104. Because of their environmental persistence, considerable efforts have been made to restrict, regulate, and in some cases, ban the uses of these materials, but it has not always been possible to find substitute materials of demonstrably lower overall impact.

105. As a group, the organohalogens have considerable practical and economic importance, except PCDD and PCDF which are unwanted by-products from the production of other organo-chlorine compounds, e.g. chlorophenols, and chlorophenoxyacetic acid pesticides. They are also produced incidentally in combustion processes at low temperature. Among other sources of PCDD and PCDF are their production during the bleaching (by chlorine) of wood pulp in the production of paper, and their production during the burning of wood treated with pentachlorophenol as a preservative. Some PCDDs and PCDFs show the hazardous properties of the organohalogens to an extreme degree. So far there have been no established effects from exposure to PCDDs and PCDFs from global environmental contamination.

106. Organohalogens, especially brominated aromatics, are also used as flame retardants but are not the most widely used materials for this purpose.

Solvents:

107. A large volume of organic materials is used as solvents e.g. in paint, varnish and cosmetics. A very large proportion of these substances evaporates into the atmosphere as a direct consequence of the mode of use. There is also a significant evaporation loss from the use of gasoline and other low- to medium-boiling point petroleum fractions. Considerable efforts are now being made to replace solvents in paint by water-based formulations. The potential

effects of these solvents in the atmosphere include odour nuisance, contribution to the greenhouse effect and some role in the production of photochemical smog. The use of solvents can also lead to the contamination of water resources by leakage from storage tanks and by discharge into sewers. This can render drinking water sources unusable without special treatment. Several health effects have been related to occupational exposure to solvents.

Detergents:

108. The major concern for the detergents is with regard to the aquatic ecosystem. Phosphate-containing detergents are a major contributor to eutrophication. Production of washing powders and detergents is about 13 million tonnes per year, of which about 40 per cent each are used in industry and households and 20 per cent for personal hygiene. The detergent builders amount to 15-85 per cent of the commercial products. As builders, predominantly poly-phosphates (mainly sodium tripolyphosphate), sodium carbonate, sodium silicate, zeolite and nitrilo-triacetic acid (NTA) are used.

109. Detergents are also used as additives to lubricants, synthetic resins, paints and varnishes, and some derivatives as emulsifiers in certain food products. The basic groups of active compounds are anionic and non-ionic; about 1 per cent only are cationic detergents, used because of their bactericidal properties. Accidental ingestion of detergents may result in poisoning of moderate severity, with no fatal outcomes except for the cationic detergents.

110. A high portion of used surfactants is released with sewage into the aquatic environment. Improper sewage treatment or persistence and ecotoxicity of some products may result in severe effects in aquatic ecosystems. Especially sensitive are the reproduction stages in aquatic organisms.

3. Control measures

111. Governments should develop risk management programmes for chemicals. These should include classification and labelling of products, and restrictions on marketing or phasing-out of specific chemicals. The availability and effects of alternatives, as well as technical, economical and social considerations, should be taken into account for risk management.

112. The use of heavy metals such as lead, cadmium and mercury should be phased out wherever possible. Recycling should be broadly encouraged, e.g. through premiums on return (such as for batteries) and environmental charges on products containing these metals. New uses of these metals should be limited.

113. The human and environmental exposure to persistent and toxic chemicals such as PCBs, dioxins, and pentachlorophenol should be drastically reduced, e.g. by product substitution, use in closed systems and banning of certain uses and products.

114. Governments should monitor human and environmental exposure to chemicals, and take regulatory action.

4. Recommendations

115. (a) Governments should strengthen national institutional arrangements to deal specifically with chemical safety issues and promote regional and international co-operation on the matter;

(b) Industry should be called upon to take responsibility for the entire life cycle of chemical products by adopting the concepts of Responsible Care and Product Stewardship;

G. Wastes

1. Background

116. Waste is of concern because its quantity, properties and global dispersion produce a threat to human health and the environment. Wastes are those materials no longer required by an individual or industry. This section focuses on the problems of solid waste disposal; liquid effluents, such as sewage, are not considered here.

117. The growth in the world's population, increasing urbanization, rising standards of living and rapid developments in technology have resulted in an increase in the volume and complexity of wastes, and in major changes in the composition of wastes, both industrial and household, over the years.

118. The volume of litter (carelessly discarded items) is of serious concern globally in both the marine and terrestrial environments.

119. Developing countries face special problems in implementing waste control strategies. These include poor control of pollution, lack of financial resources and staff with technical and managerial skills, a low level of public awareness, and lack of infrastructure for management and control.

120. The major solid waste categories are household and consumer wastes, industrial wastes, agricultural wastes, dredged spoils and sludges from sewage treatment plants.

121. There are important differences in the waste disposal problems faced by developed and developing countries and between urban and rural regions. For example, in European Community countries it is estimated that nearly 50 per cent of all waste comes from agriculture, but in some developing countries, crop residues and animal manures may not be considered as a waste problem. In developed countries there are major differences in waste quantity and quality according to the wealth of the generator and the season.

122. Industrial waste is particularly important in both developed and developing countries, as much of the waste generated is hazardous. "Hazardous wastes" pose a significant threat to human beings and the environment by virtue of their four generally recognized characteristics: flammability; corrosivity; reactivity; and/or toxicity. Other waste streams, such as household waste, may contain small quantities of hazardous wastes, e.g. batteries and "empty" pesticide containers. These small quantities of hazardous materials in non-hazardous wastes are of increasing concern in some industrialized countries. However, it should be noted that by virtue of its capacity to pollute water, household waste is hazardous, whatever any 'definition' may say.

123. It is almost impossible to obtain meaningful information on the quantities of waste production and composition of major waste streams in many countries. Important issues such as the nature of the information required, methods of assembly and quality control have yet to be resolved. Difficult though it is to collect good information, a serious attempt must be made if proper waste management is to follow.

Treatment and disposal methods:

124. Legislative frameworks are in place in many countries and controls are implemented primarily through licensing of operators and disposal sites. Licenses can be used to impose operating conditions, e.g. determining quantity and types of waste accepted at a disposal facility. In some developing countries, open uncontrolled dumps predominate and hazardous wastes are indiscriminately mixed with other materials. However, waste management practices are generally not ideal in any country.

125. There are three ways of treating waste: chemical treatment, landfill and incineration. Chemical treatment is very rarely a disposal method. Usually there is more waste after treatment than before. Because of this, and because it can involve the use of hazardous reagents and require a properly engineered plant, professionally managed chemical treatment can be expensive. There are only three reasons for using chemical treatment: to reduce the hazard of the waste, to recover useful constituents, and to make it easier or safer to dispose of the waste after treatment.

126. All methods have advantages and disadvantages and none is applicable to all wastes. The primary disadvantages of landfill are the threat of pollution to ground and surface waters, the need to manage landfill gas generated by the anaerobic biodegradation of organic materials, the attraction of vermin and pests, nuisance, the creation of contaminated land and the aesthetic damage. The primary advantages of landfill disposal are that it is commonly available; the method does not change with wide variations in the quantity and quality of the input; and the cost is comparatively low. However, site selection criteria must be properly addressed. Landfill is the most widely used disposal option.

127. Incineration is a good means for the destruction of organic wastes, but care must be exercised over the inorganics, in particular compounds such as arsenic, cadmium, lead and mercury that may be concentrated in the waste. Incineration greatly reduces the volume for landfill. The main disadvantages are the high capital and operating costs, the need for a skilled workforce to operate and manage the incinerator and the problem of disposing of solid and liquid residues. It is also a source of air pollution.

128. Significant amounts of industrial wastes, sewage sludges and dredged spoils, most of which originate in the industrial countries are dumped at sea. This practice, which may be an important source of marine pollution, is the object of regional conventions and the London Dumping Convention, which are not fully implemented.

Recycling and cleaner technology:

129. 'Clean' or 'low-waste' technology is available for many processes. There seem to be two main reasons for delay in implementation; one is attitudinal - a resistance to change, and a lack of ease when considering an unfamiliar technology. The other relates to the lifespan of very expensive existing production plants and equipment.

130. Recycling is primarily an economic activity with an environmental impact which may or may not be beneficial. When considering a recycling opportunity, it is necessary to have a very clear and precise idea of what is to be saved, and to design and monitor the process to ensure that savings are achieved. For example, in global terms aluminium recycling makes sense. Primary aluminium production frequently uses renewable (hydroelectric) energy, and it reduces the quantity of hazardous waste generated. However, most countries do not have a primary aluminium industry, so that if such a country recycles aluminium it will increase its energy consumption.

131. The practice of exporting hazardous wastes for disposal has increased. This practice is unacceptable unless it achieves safer disposal. There have been some instances in which hazardous wastes have been sent under false declarations to developing countries. The Basel Convention should prevent this in the future.

2. Human and environmental impact

132. Where treatment, incineration and landfill are used judiciously and plant design and management is of a high standard, these methods of waste disposal are effective. However, where this is not the case, serious air and water pollution occurs.

133. Leachates from landfills and runoff from land spread with agricultural wastes and sewage sludge can cause serious water pollution giving rise to eutrophication and oxygen depletion of rivers. Leachates entering groundwater are a more insidious problem and can render the groundwater unusable without extensive, difficult pretreatment. The most hazardous circumstance is where an open well used for drinking water intersects the pollution plume in the groundwater.

134. Most landfill sites generate methane, which is a potentially explosive gas and also a greenhouse gas. Poorly managed landfills may also pose a threat to human health through dust, odour, vermin and flies. The scavenging of landfills has health and safety risks.

135. Operation of incinerators can cause nuisance and atmospheric pollution from the emission of particulates, acidic gases, unburnt waste material, heavy metals and trace dioxins under certain conditions.

136. The disposal of wastes in the marine environment can have diverse and harmful effects such as the reduction or alteration of the fauna living on the sea bed and oxygen depletion with effects on fish. In addition, it may contribute to the global contamination with persistent chemicals if these are present in the dumped material.

137. Litter is a serious problem on land and at sea, aggravated by the fact that much of it is non-biodegradable. It has serious effects in the marine environment where materials such as nets, packaging and bottles are a threat to all marine life.

3. Control measures

138. For control, there must be adoption of waste reduction methods and of an appropriate waste disposal system.

4. Recommendations

139. (a) Society needs to rethink its attitude towards wastes. It should concentrate on reducing waste production as part of an overall strategy to reduce pollution rather than accept present levels;

(b) Governments should encourage the creation of an infrastructure that would permit the establishment of a national system of waste disposal controls. This requires legislation and a regulatory framework; implementation and enforcement procedures; meaningful information on waste production; and adequate facilities;

(c) Waste management strategies should emphasize waste minimization and recycling. Strong leads on these issues should be given to industry by Governments and international organizations. For example, separation at the source significantly increases the chances of successful recycling;

(d) Non-biodegradable materials cause problems for waste disposal and their use should be minimized. Plastic sheet and film are particular candidates for immediate action;

(e) Countries should ratify and implement the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.